

## Physics 230

### Homework Set 4

CQ1. Imagine you have two containers of equal amounts of oxygen gas at initially equal temperatures. You then supply equal amounts of heat to each container. The first container undergoes an *isobaric contraction* and the second container undergoes an *isochoric cooling*. After each container was heated, which has the higher final temperature? Your explanation needs to include the first law of thermodynamics.

CQ2. Knight: Conceptual Questions 9

CQ3. Knight: Conceptual Questions 11

P1. A cylinder with an initial volume of  $3.60 \times 10^3 \text{ cm}^3$  holds 0.100 mol of oxygen gas at  $120^\circ\text{C}$ . The gas is expanded by a piston to a final volume of  $5.40 \times 10^3 \text{ cm}^3$ . How much work was done on this gas if this process was done at

- a) constant pressure and
- b) constant temperature?

P2. Reconsider the isobaric and isothermal processes outlined in the previous problem.

For the *isobaric* process...

- a) *i.* What is the change in thermal energy of the diatomic gas?
- ii.* What is the heat added or removed from the gas?

For the *isothermal* process...

- b) *i.* What is the change in thermal energy of the diatomic gas?
- ii.* What is the heat added or removed from the gas?

P3. Consider the cylinder of Figure 17.13 that contains a gas that undergoes an *isobaric expansion*.

- a) Draw a  $pV$  diagram showing this process. This diagram needs to include axes labels and an arrow indicating the direction traversed between the initial and final points on the  $pV$  curve.

- b) Describe a series of steps to implement this ideal-gas process.
- c) Show the process as a first-law bar chart.

P4. Imagine two ice cubes, each with a mass of 55 grams and an initial temperature of  $-14.0^{\circ}\text{C}$ . The ice cubes are dropped into 220 grams of water, which has an initial temperature of  $26.0^{\circ}\text{C}$  and is in a thermally insulated container.

- a) What is the final temperature of the beverage once equilibrium is reached?
- b) What is the final temperature if only one ice cube is used?

P5. Consider a scenario where an unknown mass of  $100^{\circ}\text{C}$  steam is mixed with 210 g of ice, which is at its melting point. The mixing occurs in a thermally insulated container. After thermal equilibrium is reached, the liquid is found to have a temperature of  $55^{\circ}\text{C}$ . Calculate the unknown mass of the steam.

*Extra Credit Problem (+12 points):*

P6. Consider a sample of oxygen gas, which has a mass of  $M = 1.88$  g, that starts at an initial state  $A$  as indicated in the attached figure. The gas undergoes an *isobaric expansion* to a state  $B$ , then an *isochoric heating*, bringing the gas to state  $C$ . Lastly, the gas returns to state  $A$  via the path indicated in the attached figure.

- a) Calculate the temperature of the gas in Kelvin when the gas is described by states  $A$ ,  $B$ , and  $C$ , respectively.
- b) Calculate the heat,  $Q$ , work done on the gas,  $W$ , and thermal energy change,  $\Delta E_{th}$  for the gas as it goes through *each* of the three aforementioned processes.

*Notice:* for the state  $C$  to state  $A$  process, integration must be used!

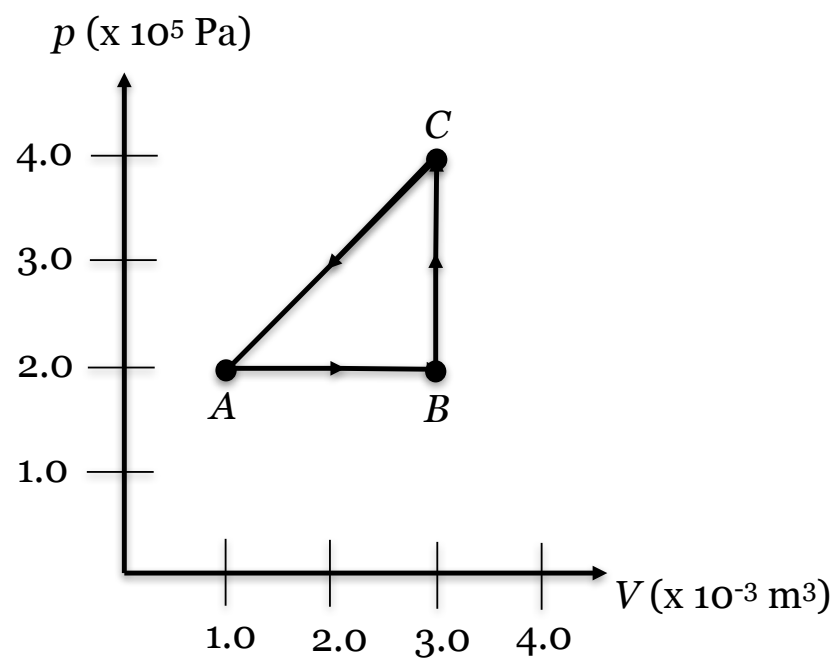


Figure 1: Pressure vs volume plot